

11 Water Pricing in Tadla, Morocco

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Introduction

In 2002, Morocco had a population of 29.6 million of which 43% lived in rural areas; about 35% of the population are farmers. Agriculture accounts for 16.1% of the GDP, and average per capita income was \$1190 (World Bank, 2003). The total area of Morocco is 71 million ha (including 26 million ha of Sahara), of which only 9 million ha are utilized as the agricultural area (13%). The average annual rainfall is less than 300mm, but is variable in time and space (50mm in Saharan zones and 2000mm in mountainous regions).

Morocco's climate makes rain-fed agriculture uncertain and of generally low productivity, especially in the southern areas where rainfall is highly variable and, on average, far less than potential evapotranspiration. Production from rain-fed arable land consequently varies widely. About 1.6 million ha can be potentially irrigated, and 1.2 million ha (75%) are currently irrigated, of which 55% is government-managed, 30% owned and managed by local communities and 15% (mostly irrigated with groundwater) privately developed (FAO, 2001).

Irrigated areas produce 45% of agricultural value added and 75% of agricultural exports (Ait Kadi, 2002). Irrigation currently accounts for 88% of water withdrawals (domestic and

industrial use account for 8% and 4%, respectively). The average availability of water is just 1045m³/person/year and projected increases in population are expected to reduce this value to about 750m³/person/year by 2020 (El Yacoubie and Belghiti, 2002).

In 1990, the estimated national water balance showed an availability of 11Bm³ with demand at 10.9Bm³. The supply of water is expected to rise to 16.8Bm³ by 2020 (as a result of dam construction and the development of additional aquifers). Demand for water is expected to be higher at 17.6Bm³, with irrigation accounting for 4.8Bm³ (70%) of this increase (Ait Kadi, 2002). Although these values are estimates, they indicate that Morocco's currently developed resources are fully utilized.

An additional concern is the deteriorating water quality, with increasing amounts of water needed to flush and dilute pollution loads (particularly high salinity and sediment).

This chapter focuses on the Tadla region. In Tadla, because of the increasing deficit of surface water farmers use groundwater. Water tables are falling and the water is often highly saline, prompting concern over the sustainability of groundwater development.

Overall, the main factor constraining agricultural production is the availability of

water. With scarcity of canal water and overexploitation of groundwater, a number of policy-relevant issues have emerged:

- Reducing overall water consumption in agriculture;
- Increasing the productivity of the water consumed;
- Balancing the supply of, and the demand for, groundwater;
- Avoiding soil and water salinization;
- Providing a sustainable water service through better maintenance and cost recovery.

The role that volumetric water pricing can play in addressing these issues in Tadla is not clear. The main aim of this chapter is to assess the potential role of the water pricing policy. To achieve this aim the way water is currently allocated will be described and insight will be provided into the price, costs and returns to irrigation water in Tadla.

First, the Tadla scheme is described. Next, the price, cost and returns to water are studied. An analytical framework is applied to assess the value of production and contribution of water to that production. Then the possible impact of policy options is described. Finally, conclusions are drawn.

The Tadla Scheme, Policies, Infrastructure and Institutions

The Tadla scheme

The Tadla region is a plain 70 km long and 40 km wide. The cultivated area covers 255,000 ha, including 137,500 ha of rain-fed land and 117,500 ha of irrigated land. The Tadla irrigation system is the oldest large-scale scheme in Morocco. First operated in 1929, it consists of two separate subnetworks of lined open canals which receive water by gravity from two dams. These subnetworks are:

- Beni Amir, right bank of river Oum Er-Rbia, 27,500 ha, irrigated from the Ahmed El Hansali dam (670 Mm³);

- Beni Moussa, left bank, 69,600 ha, irrigated from the Bin el Ouidane dam (1.30 Bm³).

According to the initial project design, Beni Amir needs 420 Mm³ of water and Beni Moussa, 710 Mm³. However, since the 1980s, considerably less water has been allocated to the scheme (see section under *Water allocation at regional level and within the scheme*). In 2003, only 150 Mm³ were available for Beni Amir and 350 Mm³ for Beni Moussa (36% and 49% of the original allocation, respectively). As a result of this deficit, private groundwater development is widespread.

Water in national policies

Irrigation-sector development

Government policy in the agriculture sector has favoured investments in irrigation since 1968, when King Hassan II decided that 1 million ha should be irrigated by the end of the 20th century (this is referred to as the 'million hectares' policy). These investments have accounted for more than 65% of the total public investments in agriculture since 1965 (Herzenni, 2001). The objectives of this investment policy and irrigation it has supported are:

- To improve self-sufficiency through a better coverage of basic food needs;
- To find an equilibrium in the 'trade balance' through the development of exports;
- To improve the living conditions of the rural population;
- To add value to agricultural products through the development of agro-industries.

Morocco has adopted an integrated approach to large-scale irrigation development. Nine modern large-scale irrigation schemes have been established; they are government planned and financed, and each is managed by a Regional Office for Agricultural Development (ORMVA). The basic philosophy is that 'to attain the desired objectives, it

is not sufficient to construct irrigation infrastructure as rapidly as possible, the state must also create the conditions enabling development to take place.' A comprehensive framework for this policy is defined by a variety of laws grouped in the Code of Agricultural Investments of 1969. The code is regarded as a contract between the state and the country's farmers to improve the national economy through irrigation development (Ait Kadi, 2002):

- The state finances the dams, the irrigation network and necessary on-farm development. Through ORMVA, it provides credit, selected seeds, fertilizer, farm equipment, etc. Finally, it guarantees the prices of certain crops (mainly sugarbeet and sugarcane) through contracts.
- In turn, the farmer is obligated to farm his irrigated land in the national interest and to repay the state 40% of the investment costs and 100% of the O&M costs through a land-improvement tax and volumetric water charges.

Water allocation and management

The original concept of irrigation in Morocco assumed relatively plentiful water, managed at project level, and provided for controlled cropping patterns, so that irrigation schedules could be set in relation to a known crop demand determined in advance by the government. This practice was abandoned in the 1980s, and farmers are now free to choose their own cropping patterns – generally increasing the potential demand. In parallel with this liberalization, water availability has declined significantly to schemes such as Tadla, and Morocco has adopted a policy of basin-level allocation of water among competing uses. Water management at scheme level is now based primarily on a rationing system, with each farmer given an entitlement of water, which the farmer may use, but there is generally less water than the farmer would wish to receive. A national program launched in 1993 aimed to increase the size of existing irrigation schemes and encourage more efficient water use.

The Water Law

A major step in water policy was achieved through the Water Law that was passed in September 1995. This law establishes institutions and defines rules for the sustainable use of water resources. Seven financially autonomous River Basin Agencies were created as a result of this law. The Agencies prepare a management plan for all water resources in their basin and implement it, deliver authorizations for any use of the public domain, and are responsible for the quantitative and qualitative monitoring of the resources.

Irrigation infrastructure and water distribution in the Tadla scheme

Water allocation at regional level and within the scheme

Among the nine large-scale irrigation schemes, the annual planned average water use is 5100 m³/ha, but varies between 3000 m³/ha/year (Tafilalet and Ouarzazate) and 7100 m³/ha/year. (Tadla) (Benjelloun Touimi, 2002).

The amount that can be delivered to farmers depends on the water allocated to the scheme; this is decided each year at the level of the River Basin Agency. The amount to be released is calculated according to the projected inflows and available reserves in the two upstream dams; the amount released may be adjusted during the year depending on the actual rainfall. This release is shared between Tadla and other downstream irrigation schemes. As a result of the chronic droughts, irrigation expansion and the demand from other schemes, the allocation to Tadla is substantially less than the amount initially designed. In 2001–2002, only 27% of what was initially designed (710 Mm³) was delivered to the scheme (Fig. 11.1).

As a result, irrigation in Tadla faces a severe shortage of water and the distribution rules have been adapted to deal with a shortage situation. Now that demand largely exceeds supply, no demand-oriented management can be carried out, and water

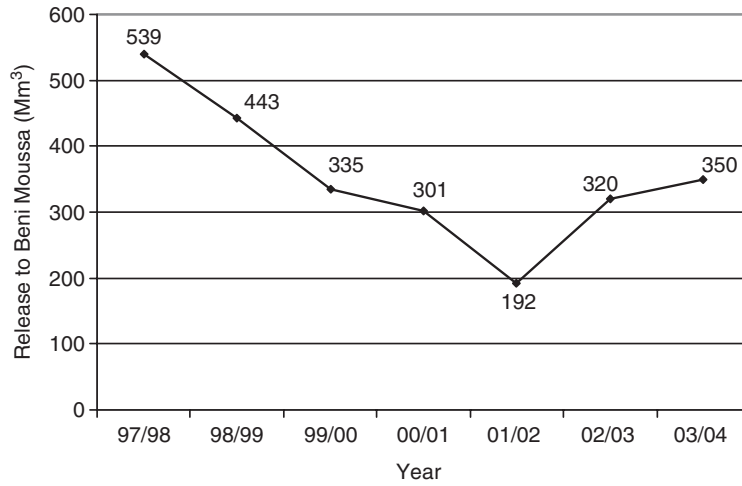


Fig. 11.1. Annual releases from the Bin El Ouidane to the Beni Moussa scheme. (From ORMVAT, 2004.)

Channel>>					
Farm 1 Plot A	Farm 1 Plot B	Farm 1 Plot C	Farm 1 Plot D	Farm 1 Plot E	Farm 1 Plot F
Farm 2 Plot A	Farm 2 Plot B	Farm 2 Plot C	Farm 2 Plot D	Farm 2 Plot E	Farm 2 Plot F
Farm 3 Plot A	Farm 3 Plot B	Farm 3 Plot C	Farm 3 Plot D	Farm 3 Plot E	Farm 3 Plot F
Farm 4 Plot A	Farm 4 Plot B	Farm 4 Plot C	Farm 4 Plot D	Farm 4 Plot E	Farm 4 Plot F
Farm 5 Plot A	Farm 5 Plot B	Farm 5 Plot C	Farm 5 Plot D	Farm 5 Plot E	Farm 5 Plot F

Fig. 11.2. Schematic of watercourse and farm plot layout (under which Trame B farms had the same cropping pattern).

allocation among farmers is based on a rationing system.

Water distribution

While the total seasonal allocation to the farmer is fixed, the schedule of delivery and the amount of water delivered at each water turn are based on the crops. In case of unexpected water scarcity during the season, priority of water delivery is given to specific crops. Farmers cannot transfer unconsumed water to another turn, so most of them take all the water they can get at each turn. Actual management therefore is effectively quota-based.

The infrastructure was designed for a specific situation, namely the irrigation of an obligatory cropping pattern at the farm level, with crops organized in homogeneous blocks served by a common watercourse. The system was logical when cropping patterns were enforced so that Plot A (Fig. 11.2: the tertiary channel is the bold line at the top; watercourses are indicated by the vertical double lines) for each farm was under the same crop and could be provided with a water delivery schedule suited to that crop (Cornish and Perry, 2003). Known as the Trame B model, this system simplified water scheduling and management because each

watercourse was operated to serve a specific crop and its specific water requirements.

However, in the 1980s cropping patterns were liberalized to enable water to be distributed on a farm basis rather than on a crop basis, with the result that the 30-year-old design no longer corresponds to the current management situation. However, the ORMVA management still issues clear 'guidance' on feasible cropping plans prior to each season, based on the anticipated water availability per hectare, and the demand of individual crops (so that farmers opt for a larger area of less water – or a smaller area of more water-demanding crops).

Each farm has six plots, arranged horizontally. The left-most watercourse first serves Farm 1 Plot A, followed by Farm 2 Plot A, through to Farm 5 Plot A. Irrigation then continues to Farm 1 Plot B on to Farm 5 Plot B, through Tertiary 2, and so on. In any given irrigation turn, a farmer would have to come back as many as six times to irrigate his farm. This operating pattern is matched by the design of the infrastructure, which has division structures at each level to ensure accurate provision of the proper discharge to each area.

In recent years, a provisional allocation has been established at the beginning of the irrigation season (September) and farmers are informed about it. During the year, the actual volume delivered to a farmer is calculated by multiplying the number of hours of his turn by the flow rate (generally 30l/s). This rationing provides a relatively transparent and equitable means of allocating water, ensuring that consumption of water is controlled.

In such a constrained system, the volumetric water fees paid by farmers (see section on *Price paid by farmers*) serve predominantly as a means of cost recovery.

Irrigation at scheme, farm and plot level

From the dam, water is conveyed by gravity through a system of concrete-lined channels, divided into a primary, secondary and tertiary levels (see Table 11.1). At the tertiary level, channels are suspended on pillars and can carry 120l/s before branching off into 30l/s earthen watercourse channels from which the farmers take water. At each branch-

Table 11.1. Cumulated length of lined channels in the Tadla irrigation scheme. (From ORMVAT, 2004.)

Channel type	Cumulated length (km)
Principal	200
Primary and secondary	360
Tertiary	1800
Total	2360

ing point, there are *modules à masque* (stepwise or baffle distributors), which provide supplies to off-taking channels, relatively independent from the upstream water level in the parent canal.

Field observations indicate that while individual modules can be adjusted to various flow rates (30, 60 or 90l/s), most are fixed at a particular rate, ensuring consistent patterns of delivery. Since the water demand schedule for the various crops is different, the watercourses are arranged to run at right angles to the ownership boundaries so that each watercourse can be operated to serve the needs of a specific crop (Fig. 11.2).

The most frequently used irrigation technique at field level is the traditional *robt*. A plot is divided into several small basins, each one of about 10 m², irrigated via *seguias* (earthen watercourses) that convey water through the farms. The initial landlevelling has been gradually degraded as a result of the agricultural practices and the manual digging of the irrigation basins and watercourses in the fields.

The ORMVAT estimates irrigation efficiency (including internal conveyance) at farm level to be 50%; that is, only half of the delivered water is directly used by the crop. Taking distribution losses into account, the overall system efficiency is even lower, namely less than 45%. However, much of this wasted water is reused in the system: many drains are tapped through individual pumping, and the infiltrated water is the major inflow to the underlying aquifer, from which a large number of farmers pump water to complement surface supply. In a way, the fact that water tables are generally falling and large-scale waterlogging is not reported suggests that the estimated losses are already

being fully exploited through local reuse. This issue is important, given the claim that reducing losses may improve availability only if 'losses' are not already being recaptured, although this particular reuse is accompanied with a decrease in water quality (Seckler, 1996; Cornish and Perry, 2003).

Groundwater use

All the latest studies (Hammani *et al.*, 2004) show that irrigation losses account for the major part of the inflow to the shallow aquifer. In the 1980s, severe and repeated droughts led many farmers to invest in pumping devices; they were encouraged to do so by the state, which provided subsidies and technical support. Nowadays, about 10,000 wells are used in the schemes and approximately 40% of the farms have wells.

Most of the pumps are powered by diesel engines, with an average discharge of 10–15 l/s. Farmers generally use groundwater to supplement surface water. As groundwater is generally more saline than surface water, conjunctive use at plot level may be necessary to avoid soil degradation and yield losses. However, farmers are much more concerned with quantity issues, and these medium-term risks are outweighed by the demand to increase the present supply (Petitguyot, 2003).

There has been a regular decline in the level of the shallow aquifer for 20 years now, and there is no regulation to control withdrawals of groundwater. As a result, many wells have dried up. Farmers who can afford new investments now deepen their wells or sink deeper tube wells (wells still represent 89% of the total but 25% are non-functional). Whereas shallow resources are of bad quality and may only be used for agriculture, deep aquifers are exploited by urban and industrial users, which will result in competition.

Institutions and governance

Water allocation in the river basin

According to the Water Law, River Basin Agencies (which are under the responsibility of the Ministry of Public Works) are in

charge of developing and allocating water resources. Each year, the agencies and the basin's stakeholders agree on a programme for water allocation. Urban and industrial needs have priority over the agriculture sector. In the Tadla area, water use for electricity production has the lowest priority, and water for irrigation is released according to agricultural needs only.

Although farmers are represented on the agency board which sets up the annual programme, their influence is negligible (2 members out of 35 on the board) and only the ORMVA may interact with a significant power to negotiate agricultural allocation.

Organization of the ORMVAT

Morocco's nine major irrigation systems are operated by ORMVAs, which are semi-autonomous, regional public institutions under the responsibility of the Ministry of Agriculture. They are in charge of agricultural development (in both the irrigated sector and the surrounding rain-fed areas), including irrigation design, O&M and fee collection. About 1000 people work at the ORMVA in Beni Mellal, which is responsible for Tadla (400 on water management, 300 on extension and agricultural development, 300 on administrative tasks).

Pricing and cost recovery

The ORMVAs' financial resources come from fees paid by users, particularly irrigation water fees, and from state subsidies (investment subsidies and/or subsidies to balance operating budgets). An ORMVA accountant (who works for the Ministry of Finance) is responsible for supervising the collection of water fees. There are two forms of cost recovery:

- Recovery at source: This method applies to farmers who have production contracts with agro-industrial units, such as sugar mills. Here, the mill pays the ORMVA any water fee due, before paying the farmer for his crop.
- Direct payment: Farmers are individually invoiced every quarter using a cus-

tomers code, with invoices delivered by the *aiguadier* (ditch rider or water guard). Payment is due twice a year. Farmers incur penalties for late or non-payment (after 1 month, suspension of supply; after 2 months, an 8% increase in the amount due; after 1 year, there should be a court action). In reality, the issue of non-payment is strongly related to land status, as farmers who share the same undivided property receive only one invoice and face difficulties with respect to the division of the bill. Instead of court action, water supply pipes to many farmers in this situation are disconnected from the network. It is worth noting that in Tadla, the rigorous management of non-payers (they are quickly disconnected) means that the level of invoice payment is very high (more than 90%).

Between 1995 and 1998, a novel system was introduced for water accounting by farmers. In pilot areas, each farmer received a water consumption 'cheque book'. For each water turn, the farmer filled in a cheque for the ditch rider, and kept a copy for his own records. A part of the annual volume was allocated to each farmer for the season but the schedule of deliveries was variable, based on individual demand (within reason and subject to competing demands). The cheque book kept a running account of the total amount of water used. This approach was an innovative means of combining rationing with flexibility (the infrastructure allows for flexible delivery of the allocated quota), but proved difficult to manage during the severe drought of 1998. However, in 2002, this system was reintroduced, and is used as an incentive for farmers who use modern irrigation techniques and are able to irrigate a larger area per unit of water delivered.

Water user associations in the Tadla area

At the beginning of the 1990s, the government decided to develop participatory irrigation management, giving farmers a greater role in irrigation management. In Tadla, farmers showed little interest in the incen-

tive offered to participate (i.e. a reduction in water fees), according to Papin (2003). Farmers also lack the historical experience in (organizing) irrigation that exists in other parts of the country. A law passed in 1990 provided a legal basis for establishing water user associations (WUAs), with responsibility for managing irrigation at the tertiary level. Tadla has 29 registered WUAs (11 in Beni Amir and 18 in Beni Moussa), representing 41% of farmers in an area covering 44,540 ha. However, most of these associations are not operational. A study carried out in 2001 (ENGREF, IAV Hassan II and CNEARC, Tadla, 2001, unpublished data) reported that only one WUA was active in Beni Moussa, and that this could be explained by a diversification of its activities to other sectors (road construction, basic education). The WUAs did not prove to be successful, and many farmers refused to pay the charges to finance a WUA. This could be seen as a compliment to the operation of the irrigation schemes by the ORMVA – the farmers found this satisfactory and did not see the need to add an additional layer of management.

Price, Costs and Returns to Water

Price paid by farmers

Surface water

Canal water fees are based on the Agricultural Investment Code of 1969 – a general law on agricultural water management, water pricing and service fee recovery. The Code provides a comprehensive cost recovery structure, including the full recovery of O&M costs (through water fees) and the partial (40%) recovery of capital costs (through the water fee), indexed over time to inflation. Water is charged on the basis of quantity received, which is metered in the case of pressurized systems and calculated on the basis of time and the nominal flow rate in the case of surface systems. Water fees can be increased, but the new fee must be approved by the Ministers of Public

Works, Agriculture, and Finance as well as by parliament.

Actual water charges in Morocco are relatively high by international standards and charged according to the volume of water delivered (although payment for at least 3000 m³/ha is obligatory). In Tadla, the canal water fee in 2002 was \$0.02/m³ (\$1.00 = MAD8.9). This was the lowest in Morocco because, unlike other areas, Tadla canal systems do not involve pump-lifts. In some regions, the rate is as high as \$0.062/m³ (Ben Abderrazik, 2002). None the less, the canal water fee in Tadla has steadily increased over time, from \$0.005/m³ in 1980, to \$0.01/m³ in 1987–1988, and to \$0.015/m³ in 1992, but this is, of course, also partly the result of inflation (El Yacoubie and Belghiti, 2002). In regions where pumping is a significant part of operational costs,¹ farmers do not pay the full O&M costs. Instead, these ORMVAs rely on an annual transfer of funds from the central government in order to meet operational expenses, and farmers are not charged for capital costs.

Groundwater

The pumping of groundwater from wells is a private undertaking of the farmers. Well owners pay the full cost of development and O&M. The energy cost can be estimated according to the discharge of the pumps (generally 15 l/s). Various sources indicate an average of \$0.03/m³ (Papin, 2003; Petitguyot, 2003; Le Grusse *et al.*, 2004). The full cost of groundwater extraction (i.e. including energy costs, amortization and pump maintenance costs) is more difficult to estimate, as it depends on the actual utilization of the pump, the head and other parameters. According to the same sources, the total cost in Tadla is around \$0.06/m³, with a high variability between farms. Some comments should be made about this value. First, it is not certain that farmers consider this total cost in their daily decisions whether to irrigate or not: investment costs are sunk costs and the marginal costs might

be more relevant. Second, Le Grusse *et al.* (2004) note that many tube wells are shared by neighbouring farms, who may thus share the investment burden and reduce the total (and hence unit) cost. Also, compared to surface water, these costs integrate neither qualitative differences such as salinity (lower in canal water) nor an insurance value (groundwater protects farmers against network deficiencies in critical growing stages) that may greatly influence farmers' choice.

Groundwater is generally regarded by farmers as a supplementary resource to be used in the case of a deficit. The gap between the groundwater and surface water tariffs is not much wide and an increase in surface water tariffs might trigger the exploitation of groundwater.

Costs of water delivery

The costs incurred by the supplier in the provision of irrigation water services in Tadla are summarized in Tables 11.2 and 11.3. Annual O&M costs are \$11.5 million (for an area of 92,000 ha), which is \$125/ha/year. Annual total costs are \$13.5 million, which is \$147/ha/year including depreciation on capital. This relatively small difference between the O&M and the full costs is because Tadla is an old project – the first large irrigation project to be built in Morocco – and was (in current prices) therefore comparatively cheap at the time of construction. It requires, however, more maintenance. For a water delivery of 7400 m³/ha, O&M costs are \$0.017/m³ and full costs are \$0.02/m³.

Official statistics indicate that current water charges cover more than the O&M costs (Table 11.4), which is consistent with the estimated farm payment for water (\$145–155/ha). If full water fee collection is achieved – i.e. if all users pay their bills in Tadla – more than 100% of the O&M expenditures are covered. The data indicate that system delivery losses (between diversion and delivery to farmers) are relatively low.

¹Electricity is charged to ORMVAs at 20% below the commercial rate – around \$0.08/kWh.

Table 11.2. Annual O&M costs including labour (without capital depreciation) in \$ million. (From ORMVAT, 2004.)

	Dept. of Irrigation and Drainage		Dept. of Construction		Dept. of Agriculture Development and Extension		Total	
	Amount	%	Amount	%	Amount	%	Amount	%
Direct costs	4.1	70	0.5	68	3.3	69	8.0	69
Indirect costs	1.8	30	0.2	32	1.5	31	3.5	31
Total costs	5.9	100	0.8	100	4.8	100	11.5	100

Table 11.3. Annual total costs (with capital depreciation) in \$ million. (From ORMVAT, 2004.)

	Dept. of Irrigation and Drainage		Dept. of Construction		Dept. of Agriculture Development and Extension		Total	
	Amount	%	Amount	%	Amount	%	Amount	%
Direct costs	5.4	71	0.6	69	3.5	70	9.5	71
Indirect costs	2.2	29	0.3	31	1.5	30	4.0	29
Total costs	7.6	100	0.9	100	5.0	100	13.5	100

Table 11.4. ORMVAT budget and expenditures (in \$). (From ORMVAT, 2004.)

Year	1996–1997	1997–1998	1998–1999
Provisional budget	11,954,205	10,493,814	10,218,438
Actual expenditure on operations	10,355,227	9,089,175	9,040,417
Pumping costs	161,250	135,361	138,854
Maintenance	58,182	100,206	86,563
Personnel	6,325,682	5,567,629	5,584,896
Costs of other operations	3,810,227	3,286,082	3,230,104
Actual expenditure on new investment	901,136	2,342,474	2,401,667
Total actual expenditure	11,256,364	11,431,649	11,442,083
Income (recovery from fees)	13,322,500	12,264,948	14,293,125

Returns to water

Agricultural production in Tadla consists predominantly of cereals (mainly wheat), sugar-beet, fodder and olive trees (Table 11.5).

A consistent analytical framework was applied to assess the returns to water for the typical cropping patterns observed for various farm sizes. The returns to water are calculated as the value of production, net of input costs, divided by the volume of irrigation

Table 11.5. Area irrigated by crop in Tadla (5-year average 1998–2003). (From Petitguyot, 2003.)

Crop	Area (ha)	%
Cereals	46,000	39
Sugarbeet	13,800	12
Fodder	25,000	21
Olive	16,800	14
Citrus	8,100	7
Vegetables	8,500	7

Table 11.6. Summary data for Tadla. (From Hellegers and Perry, 2004.)

Farm	1	2	3
Size (ha)	4.8	6.0	7.7
Gross income (\$/ha)	1453	1971	996
Net income before water charges (\$/ha)	901	1470	612
Water charge if 100% canal (\$/ha) ^a	156 (17)	145 (10)	145 (23)
Water charge if 100% well (\$/ha) ^a	320 (35)	297 (20)	298 (49)

^aValues within parentheses indicate % of net income.

water used. The appendix shows the results of a farm survey for three farms in Tadla, ranging in size from 4.8 to 7.7 ha. The first three tables show farm income assuming that irrigation is fully from canal water, while the last three tables show farm income assuming that irrigation is fully from groundwater. In fact, however, most farms use a mixture of sources. The exact mix could not be accurately assessed, so the calculations estimate the extreme cases.

The main crops grown on these farms include wheat (including seed multiplication), fodder crops (lucerne, berseem) and olives. The returns to wheat and broad bean are relatively high compared to the returns to lucerne, which may be explained by the relatively low price of lucerne, as it is often used as fodder for livestock. The appendix shows that the net return to water is about \$0.10/m³.

The key data for this study, summarized in Table 11.6, are gross income per hectare, net income (before water charges) and the proportion of net income (before deduction of water charges) accounted for by water charges. It is important to note that agricultural income given in Table 11.6 relates to crop production only.

These data indicate that farmers in Tadla spend a substantial proportion of their net income (10–23%) on canal irrigation services and even more (20–49%) if they irrigate entirely with groundwater. These results should be considered with care as they do not represent the high variability of production systems in Tadla. They are, however, consistent with other results found by Petitguoyot (2003).

Discussion of price, costs and returns to water

The O&M cost of water delivered at the field in Tadla is \$0.017/m³, while the full cost is \$0.02/m³. The current volumetric canal water fee is high (\$0.02/m³) compared to other similar case studies and covers the O&M costs. The marginal cost of groundwater is \$0.03/m³. The costs of canal and groundwater are, however, less than the return to irrigation water (\$0.1/m³). As farmers spend a substantial proportion of their income on canal water, it is likely that current prices discourage wastage and give an incentive to concentrate usage on productive crops. It is, however, not likely that it will balance water supply and demand.

Possible Impact of Policy Options

Groundwater

As far as groundwater is concerned, the principle of state ownership of water has been in place since 1914. To stabilize groundwater extraction, the sustainable aquifer yield and the demand for groundwater need to be balanced. However, there are currently no defined entitlements for the use of groundwater. There is a restriction on the pumping of groundwater (i.e. no deeper than 40 m below the soil surface), although in practice this is rarely enforced and is therefore no effective policy instrument. The majority of farmers

install wells without obtaining the required authorization.

An alternative policy instrument aimed at limiting groundwater extraction is currently being drawn up. Under the Water Law, the River Basin Agency is empowered to impose a tax on each volume of water extracted from individual wells ('consumer pays' principle). The administrative costs and technical complexity of charging for extraction on the basis of the number of pumping hours – as currently proposed by the government – would be high, and will not guarantee a reduction in usage (although the implied increase in the unit price of water will provide some incentive to reduce usage there is no assurance that sustainable supply and demand will be properly balanced). Given the problems with the enforcement of existing regulations on the installation and operation of pumps, it is not certain whether hours pumped will be easy to measure and used as an instrument for demand management. It is likely that bribery would increase and meters would be tampered with.

Canal water

The volumetric canal water charge will not reduce water consumption substantially as the level of the charge is only 20% of the returns to water. Rationing eventually governs demand. The present system of charging for canal water would not, in the absence of rationing, achieve a balance between supply and demand. A considerable increase in the price of water would be needed to balance the supply of, and the demand for, canal water. However, such an increase would lead to a significant fall in the returns to agriculture and increased migration to cities.

An additional threat posed by increasing canal water fees is that such an increase is likely to lead to the increased exploitation of groundwater. Moreover, although the recovery of charges is exceptionally high in Tadla, and further increases in canal water fees might reduce the rate of recovery, as has occurred in many other schemes in

Morocco, where water fees have increased but not the total income of the water manager.

Further, a substantial increase in charges is likely to lead to a decrease in the rate of recovery, as suggested by El Gueddari (2002), who shows that in Morocco the rise in fees up to the O&M cost level has been paralleled by a decline of fee recovery from over 70% down to 55%. In Tadla, recovery is extremely high because of the strict application of the disconnection procedure in case of non-payment but a total of 8% of the farms are nevertheless reported to have been disconnected and only survive on groundwater (Petitguyot, 2003).

Rationing is therefore a more suitable instrument to govern demand and to foster the productive use of water.

A particular difficulty with volumetric water charges is that they do not ensure appropriate cost revenue levels for the scheme manager. In a dry year, there will be limited water to sell, and revenues will fall proportionately. In a year of high rainfall, demand for irrigation water will be limited, leading to revenue shortfalls. A two-part tariff (a fixed and a volumetric tariff) provides additional security of revenues to the manager.

In summary, Tadla has a technically sophisticated surface irrigation system capable of delivering differentiated irrigation schedules to individual farmers, but simple quota-based rationing is the basis for constraining demand. Volumetric water charges are only used to achieve cost recovery. It should be noted that to overcome scarcity of surface water, many farmers have invested in private tube wells, and that the unit price of this water is more than double that of the supplied surface water. Any increase in water tariff should be considered relative to the impact on this complementary resource, the use of which is not regulated.

Synthesis

The availability of water is, and will continue to be, the key factor constraining agricultural production in Tadla. Deteriorating

water quality increases this concern. The scarcity of canal water and the significant exploitation of groundwater in dry years have led to the identification of several policy objectives, e.g. to reduce overall water consumption in agriculture, to increase the productivity of water, to balance the supply of, and demand for, groundwater, to avoid soil and water salinization and to provide a sustainable water service through better maintenance and cost recovery. The main aim of this chapter was to study the potential role of pricing policy in meeting these objectives.

The volumetric canal water fees currently charged in Tadla (\$0.02/m³) cover the O&M costs, but are only about one-fifth of the estimated return to water (\$0.1/m³). Such fees will not reduce water consumption, as supply is rationed through quotas at levels well under crop requirements and which preclude significant savings.

Balancing supply and demand through volumetric charges would require a very considerable increase in the price of water. This is not desirable for two reasons: an increase in the price of canal water would significantly reduce farm incomes, and such an increase could trigger an increase

in the use of groundwater. Rationing, which is already used in Tadla, seems the most suitable instrument to govern demand for canal water, and has the additional benefits of low transaction costs, equity and transparency.

Under the current system in Morocco, the regional ORMVAT is responsible for the distribution and allocation of water from the principal canal down to individual farms, and for maintaining the system. The ORMVAT also collects water fees and plays a role in planning cropping patterns and providing agronomic advice.

Thus, Morocco is already using very suitable instruments – namely rationing and some volumetric charging – to govern the demand for canal water and to recover O&M costs. However, attention needs to be paid to policies to control groundwater use in an effective way.

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Appendix: Overview of the Outcome of the Spreadsheets

Table 11.A.1. Tadia farm budgets – canal irrigated. (From Hellegers and Perry, 2004.)

Farm 1 4.8 ha	Income per ha \$	Crop area ha	Farm income \$	Input costs \$	Labour costs \$	Water costs \$	Net income \$	Family labour use days	Family labour return \$/day	Water use 000m ³	Gross water return \$/m ³	Net water return \$/m ³
Sugarbeet	1060	1.0	1058	443	165	155	295	59	5	7.8	0.1	0.1
Wheat	2680	0.8	2135	195	25	64	1851	22	83	3.2	0.7	0.6
Lucerne	1080	1.8	1944	1466	48	415	15	53	0	20.7	0.1	0.0
Broad bean	1645	0.6	987	60	6	43	878	27	33	2.2	0.5	0.4
Olive 1	920	0.6	552	68	86	52	345	21	16	2.6	0.2	0.2
Berseem	498	0.6	299	69	21	21	189	5	35	1.0	0.3	0.2
Totals		5.4	6976	2301	352	750	3573	188	19	37.5	0.2	0.1

Cropping intensity = 112%; utilization of family labour = 78%; proportion of family labour in total used = 70%.

Farm 2 6 ha	Income per ha \$	Crop area ha	Farm income \$	Input costs \$	Labour costs \$	Water costs \$	Net income \$	Family labour use days	Family labour return \$/day	Water use 000m ³	Gross water return \$/m ³	Net water return \$/m ³
Sugarbeet	1400	2.0	2772	1062	506	308	895	74	12	15.4	0.2	0.1
Wheat	2033	2.0	4025	421	147	160	3298	34	97	8.0	0.5	0.4
Broad bean	1410	1.0	1404	102	60	72	1170	47	25	3.6	0.4	0.3
Paprika	2600	1.0	2590	442	9	203	1936	3	565	10.1	0.3	0.2
Olive 2	1040	1.0	1036	83	178	127	648	26	25	6.4	0.2	0.1
Totals		6.9	11,827	2110	900	870	7947	184	43	43.5	0.3	0.2

Cropping intensity = 116%; utilization of family labour = 77%; proportion of family labour in total used = 46%.

Farm 3 7.7 ha	Income per ha \$	Crop area ha	Farm income \$	Input costs \$	Labour costs \$	Water costs \$	Net income \$	Family labour use days	Family labour return \$/day	Water use 000m ³	Gross water return \$/m ³	Net water return \$/m ³
Sugarbeet	600	1.5	901	672	4	234	(8)	118	(0)	11.7	0.1	0.0
Wheat	1550	3.4	5251	664	28	273	4286	84	51	13.7	0.4	0.3
Lucerne	480	2.6	1246	1543	14	598	(909)	245	(4)	29.9	0.0	0.0
Broad bean	1410	0.2	271	26	0	14	231	9	25	0.7	0.4	0.4
Totals		7.7	7669	2905	46	1118	3600	456	8	55.9	0.1	0.1

Cropping intensity = 100%; utilization of family labour = 63%; proportion of family labour in total used = 97%.

Table 11.A.2. Tadla farm budgets – groundwater irrigated. (From Hellegers and Perry, 2004.)

Farm 1 4.8 ha	Income per ha \$	Crop area ha	Farm income \$	Input costs \$	Labour costs \$	Water costs \$	Net income \$	Family labour use days	Family labour return \$/day	Water use 000m ³	Gross water return \$/m ³	Net water return \$/m ³
Sugarbeet	1060	1.0	1058	443	165	318	132	59	2	7.8	0.1	0.1
Wheat	2680	0.8	2135	195	25	132	1784	22	80	3.2	0.7	0.6
Lucerne	1080	1.8	1944	1466	48	850	(420)	53	(8)	20.7	0.1	0.0
Broad bean	1645	0.6	987	60	6	89	832	27	31	2.2	0.5	0.4
Olive 1	920	0.6	552	68	86	106	291	21	14	2.6	0.2	0.2
Berseem	498	0.6	299	69	21	43	167	5	31	1.0	0.3	0.2
Totals		5.4	6976	2301	352	1538	2785	188	15	37.5	0.2	0.1
Cropping intensity = 112%; utilization of family labour = 78%; proportion of family labour in total used = 70%.												
Farm 2 6 ha	Income per ha \$	Crop area ha	Farm income \$	Input costs \$	Labour costs \$	Water costs \$	Net income \$	Family labour use days	Family labour return \$/day	Water use 000m ³	Gross water return \$/m ³	Net water return \$/m ³
Sugarbeet	1400	2.0	2772	1062	506	631	572	74	8	15.4	0.2	0.1
Wheat	2033	2.0	4025	421	147	327	3130	34	92	8.0	0.5	0.4
Broad bean	1410	1.0	1404	102	60	147	1095	47	23	3.6	0.4	0.3
Paprika	2600	1.0	2590	442	9	416	1723	3	503	10.1	0.3	0.2
Olive 2	1040	1.0	1036	83	178	261	514	26	20	6.4	0.2	0.1
Totals		6.9	11827	2110	900	1783	7034	184	38	43.5	0.3	0.2
Cropping intensity = 116%; utilization of family labour = 77%; proportion of family labour in total used = 46%.												
Farm 3 7.7 ha	Income per ha \$	Crop area ha	Farm income \$	Input costs \$	Labour costs \$	Water costs \$	Net income \$	Family labour use days	Family labour return \$/day	Water use 000m ³	Gross water return \$/m ³	Net water return \$/m ³
Sugarbeet	600	1.5	901	672	4	479	(253)	118	(2)	11.7	0.1	0.0
Wheat	1550	3.4	5251	664	28	560	3999	84	48	13.7	0.4	0.3
Lucerne	480	2.6	1246	1543	14	1226	(1537)	245	(6)	29.9	0.0	0.0
Broad bean	1410	0.2	271	26	0	28	216	9	23	0.7	0.4	0.4
Totals		7.7	7669	2905	46	2293	2425	456	5	55.9	0.1	0.1
Cropping intensity = 100%; utilization of family labour = 63%; proportion of family labour in total used = 97%.												

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